

LQXB03 Test Report

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Quench Training

In the first test cycle, MQXB06 was ramped to 13000 A (234 T/m^1) without quenching exceeding the quench training requirement of 230 T/m . It was then ramped down to 12200 A (220 T/m). A trip was then induced with heater delay 0. MQXB05 quenched at 12495 (225 T/m), then at 12905 A (232 T/m).

Quench training results are compared to previous magnets in Fig. 1. Table 1 is a list of quenches executed as part of quench current studies. Note that several high current trips on the leads are included for MQXB06. The magnet was quenched at high current when the heaters fired.

Summary: Quench performance was better than that of the model magnets and the prototype. The requirements for acceptance are satisfied.

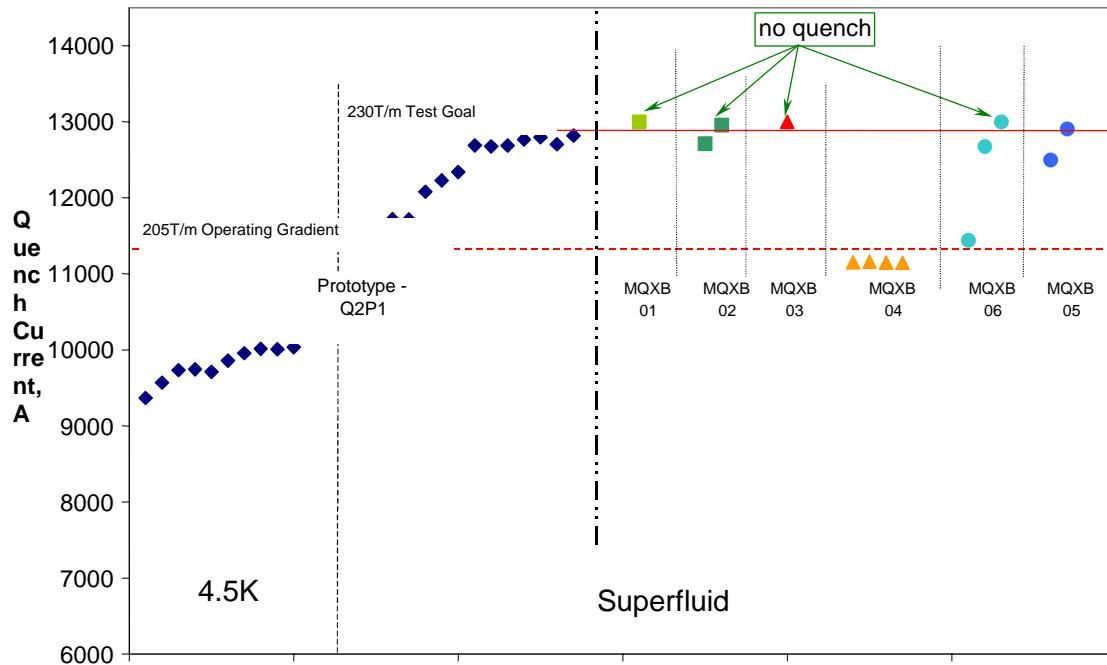


Figure 1: LQXB03 quench training. The horizontal dashed and solid lines correspond to 205 and 230 T/m field gradient respectively.

¹Gradiant quoted is body gradiant based on HGQ09 body transfer function measurements.

Table 1: List of quenches

date	time	test cycle	current (A)	ramp rate (A/s)	location	gradient (T/m) ²
<i>MQXB06</i>						
11/5/03	1805	1	11441	20	leads trip	207
11/7/03	1424	1	12674	20	leads trip	228
11/07/03	1756	1	13000	20	no quench	234
11/07/03	1756	1	12200	-	tripped, no heater delay	220
<i>MQXB05</i>						
11/12/03	1321	1	12495	20	Q2	225
11/12/03	1747	1	12905	20	Q2	232

Magnetic Field Quality Measurements

Field quality measurements were made with rotating coils. Integral field measurements were made with a multi-sectioned probe of 3 sections matched to the pitch length of the inner coil with one pitch length between sections. Complete longitudinal scans were made with a probe of length 0.82 m. The program consisted of the following measurement types.

- A “DC loop” in which the magnet was ramped in a series of steps with the field characterized at DC field at each level on the up and down ramp which we use to establish both the upramp and the geometric component of the harmonic. This is done with the integral probe. No such measurement was made as they are redundant with the longitudinal scans with the short probe.
- A prototypical accelerator cycle in which the field was measured during a conditioning pre-cycle to full field followed by a ramp down, a stop at an extended injection porch with a ramp to full field afterwards. This serves to characterize the field at injection including decay and snapback effects. These are typical done with the integral probe; however in these 2 magnets we did cycles with the short probe in the magnet body and in the magnet ends.
- Continuous measurements during a series of ramps to full field and back at different ramp rates to check for eddy current effects. These are done with the integral probe. (Note that the aforementioned accelerator cycle is a 10 A/s loop; 40 and 80 A/s loops were also done.)
- A DC loop with a longitudinal scan at each stopping point. This allows body-end field separation. These scans may be integrated to provide a characterization of the entire magnet.
- A cleansing quench preceded the accelerator cycle measurement with the integral probe.

² This is the equivalent body gradient based on HGQ09 measurements. The [linear fit parameters](#) to the high current transfer function are slope 0.0174 and intercept 7.34.

A list of the measurements made is given in Appendix A. Data is posted at the following URL.

http://wwwtsmtf.fnal.gov/~dimarco/usrAnalysisLQX/web_summaries/LQXB03/magneticMeasurements/LQXB03_mag_meas.html

Tables 2-4 summarize the field quality measurements with respect to the harmonics acceptance criteria³ for the magnet.

Table 2: Integral Field Harmonics for LQXB03

	LQXB03		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	0.20222	0.19828	T/A
ML			m
FD	0	0	mrad
b3	-0.12	-0.10	units
b4	0.50	0.19	units
b5	0.17	-0.05	units
b6	-0.87	0.19	units
b7	0.00	-0.02	units
b8	0.04	0.01	units
b9	-0.05	-0.03	units
b10	-0.08	-0.03	units
a3	-0.32	-0.36	units
a4	-0.09	-0.19	units
a5	-1.31	-0.24	units
a6	-0.25	0.08	units
a7	0.03	0.03	units
a8	-0.03	-0.01	units
a9	-0.08	-0.05	units
a10	0.09	0.04	units

³ Acceptance criteria for harmonics are from v7 of the acceptance document. [Acceptance bands](#) are from v3.2 of the reference harmonics table. The method for calculation of integral harmonics is given in Appendix D.

Table 3: Integral Field Harmonics for MQXB05

	MQXB05		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	n.a.	n.a.	T/A
ML	n.a.	n.a.	m
FD	0	0	mrad
b03	1.03	0.85	units
b04	0.29	0.20	units
b05	-0.45	0.08	units
b06	-1.13	0.14	units
b07	0.02	0.03	units
b08	0.02	0.02	units
b09	0.03	0.02	units
b10	-0.09	-0.04	units
a03	0.40	0.48	units
a04	-0.24	0.07	units
a05	-0.89	-0.29	units
a06	0.27	-0.07	units
a07	0.01	-0.02	units
a08	-0.01	0.00	units
a09	-0.12	-0.07	units
a10	-0.09	-0.04	units

Table 4: Integral Field Harmonics for MQXB06

	MQXB06		
	669 A (12.3 T/m)	11345 A (205 T/m)	Unit
TF	n.a.	n.a.	T/A
ML	n.a.	n.a.	m
FD	0	0	mrad
b03	0.80	0.64	units
b04	0.70	0.19	units
b05	-0.11	-0.03	units
b06	-0.61	0.23	units
b07	0.02	-0.01	units
b08	0.06	0.00	units
b09	-0.08	-0.04	units
b10	-0.06	-0.02	units
a03	-1.04	-1.20	units
a04	-0.41	-0.32	units
a05	-1.73	-0.19	units
a06	-0.24	0.08	units
a07	0.05	0.07	units
a08	-0.07	-0.02	units
a09	-0.04	-0.03	units
a10	0.08	0.03	units

Summary: Field quality is good. Most harmonics are within one sigma of the target. A couple of low order skew harmonics (a₅, a₆) are outside the 3 sigma limit at injection. This is due to a small amount of hysteresis unanticipated by the reference table. (This was seen for a₆ in LQXB01.) The higher order harmonics outside the 3 sigma limit are not likely real but due to limits in the resolution of the measurement system.

Magnetic Field Strength Measurements

SSW measured integral field strength with magnets powered individually and in series is given in Table 3.

Table 5: Field strength vs. current.

Current (A)	integral gradient transfer function (T/kA)	integral field strength(T)
	Q2a+Q2b	Q2a+Q2b
669	202.22	135.3
5460	200.96	1097.2
11345	198.28	2249.5

Summary: The strength at 11345 A is within the acceptance band of 2254.8±5.7. (This corresponds to the band of 1127±4 T for a single cold mass.)

Alignment

LQXB03 had alignment measurements at each stage of testing at MTF: dates are summarized in Table 6. There were also measurements and lug adjustment during mounting of the magnet prior to 30Oct03 to optimize warm alignment.

The magnet positions changed significantly during first cooldown with the weld end of Q2b and the far end of Q2a changing vertically by about 0.75mm. There were also large changes horizontally, with the both ends of Q2a shifting by about ± 1 mm and the far end of Q2b changing by about 0.75mm. The cold mass positions did not return to the initial conditions upon warm-up after TC1.

Strength measurements on the combined Q2a+Q2b were performed at 1.9K during the first TC though at a limited set of currents.

Second and third thermal cycles were performed to 4.5K to check that alignment changes were stable. The cold positions TC2 and TC3 reproduced fairly well, as did the warm measurements after these test cycles.

No adjustment of the lugs was performed after cold testing.

A partial list of the measurements performed is given in Table 6 with a full list in Appendix B.

Table 6: Major alignment data sets

Warm before TC1	30Oct03
Cold TC1	20Nov03
Warm after TC1	05Dec03
Cold TC2	08Dec03
Warm after TC2	15Dec03
Cold TC3	18Dec03
Warm after TC3	07Jan04

Data are posted at the following URL.

http://wwwtsmtf.fnal.gov/~dimarco/usrAnalysisLQX/LQXB03/SSW/LQXB03_align.html

Relative alignment of the magnet assemblies compared to AP requirements is given in Table 7. A summary plot showing the changes in cold mass positions at various points in

Table 7: Relative alignment of magnet assemblies (cold).

relative alignment of MQX magnets in composite Q2			relative alignment	
			x	y
Q2a/Q2b transverse alignment	500 μm		3386	1486
Q2a/Q2b relative roll	1 mrad (rms)		0.36	
Q2a/Q2b relative pitch	0.1 mrad		-0.03	
Q2a/Q2b relative yaw	0.1 mrad		0.57	
relative alignment of MCBX to Q2				
corrector displacement	500 μm		n.a.	
corrector roll	5 mrad			
b1			2	
a1			1.9	

the test program is shown in Fig. 2. The positions are given relative to the Cold TC3 measurements being on the average axis.

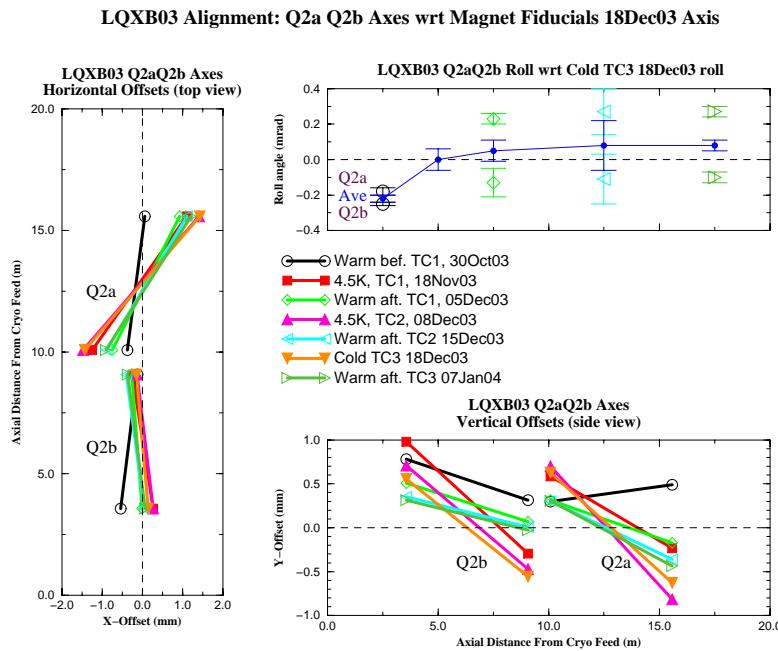


Figure 2: Alignment summary plot.

Summary: Significant changes were seen horizontally and vertically in the cold masses during cooldown and the cold masses did not return to their initial positions after the first TC. Second and third TC alignment shows that the new positions are stable and that the

warm/cold changes are now predictable. Further lug adjustment may be necessary after review wrt tolerances.

Other tests performed

The corrector was powered for testing of the corrector and corrector power supply.

Other items of interest

Appendix A: List of field quality measurements

Note that a longitudinal scan of the magnetic field with a rotating coil of the warm collered coil and cold mass were made during production as part of the quality assurance program but are not listed here.

q2a (MQXB06), tc1				
size	date	unpacked file name	probe	remarks
			IP=integral	
			SP=short	
144134	Nov 10 2003	q2a_11063do_tf.dat	SP	z scan stop dow n at 11345 A
183315	Nov 10 2003	q2a_11063up_tf.dat	SP	z scan stop up at 11345 A
201258	Nov 10 2003	q2a_11922_tf.dat	SP	z scan stop at 11922 A
145773	Nov 10 2003	q2a_5449do_tf.dat	SP	z scan stop dow n at 5449 A
201305	Nov 10 2003	q2a_5449up_tf.dat	SP	z scan stop up at 5449 A
490381	Nov 10 2003	q2a_accprofile_short_tf.dat	SP	acc profile at the end of the measurements
419740	Nov 10 2003	q2a_accProfile_tf.dat	IP	acc profile at the beggining of the measurements
381151	Nov 10 2003	q2a_loop40As_tf.dat	IP	Loop 40 A/s
230299	Nov 10 2003	q2a_loop80As_tf.dat	IP	Loop 80 A/s
q2b (MQXB05), tc1				
148303	Nov 19 2003	q2b_11334do_tf.dat	SP	z scan stop dow n at 11345 A
151957	Nov 19 2003	q2b_11334up_tf.dat	SP	z scan stop up at 11345 A
184999	Nov 19 2003	q2b_11922_tf.dat	SP	z scan stop at 11922 A
144849	Nov 19 2003	q2b_5449do_tf.dat	SP	z scan stop dow n at 5449 A
145761	Nov 19 2003	q2b_5449up_tf.dat	SP	z scan stop up at 5449 A
210380	Nov 19 2003	q2b_669up_tf.dat	SP	z scan stop dow n at 5449 A
282066	Nov 19 2003	q2b_669up_tf_orig.dat	SP	z scan stop up at 669 A
503747	Nov 19 2003	q2b_accprofile_short_le_tf.dat	SP	acc profile at the lead end
494989	Nov 19 2003	q2b_accprofile_short_re_tf.dat	SP	acc profile at the lead end
478359	Nov 19 2003	q2b_accprofile_short_tf.dat	SP	acc profile at the end of the measurements
475434	Nov 19 2003	q2b_accProfile_tf.dat	IP	acc profile at the beggining of the measurements
397133	Nov 19 2003	q2b_loop40As_tf.dat	IP	Loop 40 A/s
233255	Nov 19 2003	q2b_loop80As_tf.dat	IP	Loop 80 A/s

Appendix B: List of alignment measurements

LQXB03 SSW Measurements Log

(Column 1 is status: R indicates used directly for results; "a" indicates ancillary)

```
=====
Production measurements in ICB
=====
/usr/analysis/LQX/LQXB03/SSW
=====
a 030819_10:59 ICB/afterWeld_Q2A_stageBEnd/030819_10:59.adjY
a 030819_08:25 ICB/afterWeld_Q2A_stageBEnd/030819_08:25.testXY
a 030819_08:54 ICB/afterWeld_Q2A_stageBEnd/030819_08:54.sagCalXY
R 030821_10:59 ICB/afterWeld_Q2A_stageBEnd/030821_10:59.checkXY_unclamped
a 030821_11:57 ICB/afterWeld_Q2A_stageBEnd/030821_11:57.roll_unclamped
R 030821_12:42 ICB/afterWeld_Q2A_stageBEnd/030821_12:42.roll_unclamped
a 030821_14:29 ICB/afterWeld_Q2A_stageBEnd/030821_14:29.checkY_unclamped
a 030821_16:14 ICB/afterWeld_Q2A_stageBEnd/030821_16:14.checkXY_onAxis
a 030819_11:29 ICB/afterWeld_Q2B_stageAEnd/030819_11:29.wireSag
a 030819_12:59 ICB/afterWeld_Q2B_stageAEnd/030819_12:59.checkXY
a 030819_16:50 ICB/afterWeld_Q2B_stageAEnd/030819_16:50.checkXY
a 030820_13:50 ICB/afterWeld_Q2B_stageAEnd/030820_13:50.checkXY
R 030821_08:40 ICB/afterWeld_Q2B_stageAEnd/030821_08:40.checkXY_unclamped
a 030821_08:59 ICB/afterWeld_Q2B_stageAEnd/030821_08:59.checkY_unclamped
a 030821_09:26 ICB/afterWeld_Q2B_stageAEnd/030821_09:26.checkY_unclamped
a 030821_09:38 ICB/afterWeld_Q2B_stageAEnd/030821_09:38.checkY_unclamped
a 030821_10:02 ICB/afterWeld_Q2B_stageAEnd/030821_10:02.roll_unclamped
a 030821_15:04 ICB/afterWeld_Q2B_stageAEnd/030821_15:04.checkY_unclamped
R 030821_15:21 ICB/afterWeld_Q2B_stageAEnd/030821_15:21.roll_unclamped
a 030617_14:00 ICB/initialAlign_QA_stageAEnd/030617_14:00.sagCal_QA
a 030617_13:11 ICB/initialAlign_QA_stageAEnd/030617_13:11.checkXY
R 030617_15:27 ICB/initialAlign_QA_stageAEnd/030617_15:27.checkXY
R 030617_16:06 ICB/initialAlign_QA_stageAEnd/030617_16:06.rollMeas
R 030709_09:43 ICB/initialAlign_QA_stageAEnd/030709_09:43.checkXY_roll_adjSupport
R 030617_17:18 ICB/initialAlign_QA_stageBEnd/030617_17:18.sagCal_XYcheck_roll
a 030707_08:28 ICB/initialAlign_adj1_QA_stageAEnd/030707_08:28.checkXY
a 030619_12:03 ICB/initialAlign_adj1_QA_stageAEnd/030619_12:03.rollMeas
a 030707_09:56 ICB/initialAlign_adj1_QA_stageAEnd/030707_09:56.rollMeas
R 030707_11:19 ICB/initialAlign_adj1_QA_stageAEnd/030707_11:19.checkXY_isovTaps
R 030707_11:51 ICB/initialAlign_adj1_QA_stageAEnd/030707_11:51.checkRoll_isovTaps_repeat/030707_11:51.checkRoll_isovTaps
R 030707_11:51 ICB/initialAlign_adj1_QA_stageAEnd/030707_11:51.checkRoll_isovTaps_repeat/030707_12:49.checkRoll_isovTaps
R 030709_09:43 ICB/initialAlign_adj1_QA_stageAEnd/030709_09:43.checkXY_roll_adjSupport
R 030710_10:13 ICB/initialAlign_adj1_QA_stageAEnd/030710_10:13.checkXY_roll_adjSupport2
a 030619_10:40 ICB/initialAlign_adj1_QB_stageBEnd/030619_10:40.checkXY
a 030619_11:12 ICB/initialAlign_adj1_QB_stageBEnd/030619_11:12.checkRoll_adj1
R 030707_14:30 ICB/initialAlign_adj1_QB_stageBEnd/030707_14:30.checkXY
R 030707_15:12 ICB/initialAlign_adj1_QB_stageBEnd/030707_15:12.rollIcheck
a 040220_15:41 ICB/afterMTF_correctorAngle/QA/040220_15:41.testMeas
a 040220_15:54 ICB/afterMTF_correctorAngle/QA/040220_15:54.roll
a 040220_16:20 ICB/afterMTF_correctorAngle/QA/040220_16:20.dipCor1
a 040220_16:30 ICB/afterMTF_correctorAngle/QA/040220_16:30.dipCor1
a 040220_16:41 ICB/afterMTF_correctorAngle/QA/040220_16:41.dipCor2
a 040220_16:49 ICB/afterMTF_correctorAngle/QA/040220_16:49.dipCor2
a 040220_17:02 ICB/afterMTF_correctorAngle/QA/040220_17:02.dipCor2
a 040220_17:14 ICB/afterMTF_correctorAngle/QA/040220_17:14.dipCor2
a 040220_17:23 ICB/afterMTF_correctorAngle/QA/040220_17:23.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat/040220_17:36.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat/040220_17:43.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat/040220_17:51.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat/040220_17:59.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat/040220_18:06.dipCor1
a 040220_17:36 ICB/afterMTF_correctorAngle/QA/040220_17:36.dipCor1_repeat
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor1_repeat/040223_10:50.dipCor1
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor1_repeat/040223_10:58.dipCor1
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor1_repeat/040223_11:06.dipCor1
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor1_repeat/040223_11:14.dipCor1
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor1_repeat/040223_11:21.dipCor1
R 040223_10:50 ICB/afterMTF_correctorAngle/QA/040223_10:50.dipCor2_repeat/040223_12:09.dipCor2
R 040223_12:09 ICB/afterMTF_correctorAngle/QA/040223_12:09.dipCor2_repeat/040223_12:19.dipCor2
R 040223_12:09 ICB/afterMTF_correctorAngle/QA/040223_12:09.dipCor2_repeat/040223_12:26.dipCor2
R 040223_12:09 ICB/afterMTF_correctorAngle/QA/040223_12:09.dipCor2_repeat/040223_12:34.dipCor2
R 040223_12:09 ICB/afterMTF_correctorAngle/QA/040223_12:09.dipCor2_repeat/040223_12:41.dipCor2
R 040223_12:09 ICB/afterMTF_correctorAngle/QA/040223_12:09.dipCor2_repeat
a 040223_14:57 ICB/afterMTF_correctorAngle/QA/040223_14:57.Q2s_roll
a 040223_14:16 ICB/afterMTF_correctorAngle/QA/040223_14:16.dipCor2_rot
a 040223_14:36 ICB/afterMTF_correctorAngle/QA/040223_14:36.dipCor1_rot
a 040223_15:18 ICB/afterMTF_correctorAngle/QA/040223_15:18.Q2s_roll
a 040224_16:48 ICB/afterMTF_correctorAngle/QA/040224_16:48.dipCor2
a 040224_17:08 ICB/afterMTF_correctorAngle/QA/040224_17:08.dipCor2_rotWire
a 040225_10:54 ICB/afterMTF_correctorAngle/QA/040225_10:54.dipCor2_rotWire
a 040225_13:30 ICB/afterMTF_correctorAngle/QA/040225_13:30.dipCor2_signed
a 040225_13:40 ICB/afterMTF_correctorAngle/QA/040225_13:40.dipCor2_signed_repeat/040225_13:40.dipCor2_signed
a 040225_13:40 ICB/afterMTF_correctorAngle/QA/040225_13:40.dipCor2_signed_repeat/040225_13:52.dipCor2_signed
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a 040225_13:40 ICB/afterMTF_correctorAngle/QA/040225_13:40.dipCor2_signed_repeat/040225_14:10.dipCor2_signed
a 040225_13:40 ICB/afterMTF_correctorAngle/QA/040225_13:40.dipCor2_signed_repeat
=====
```

MTF Measurements

```
=====
/usr/analysis/LQX/LQXB01/SSW
=====
=====
Adjustments during mounting before TCL
=====
a 031017_13:47 MTF_mounting/QA/031017_13:47.checkXY
=====
```

```

a 031017_14:02 MTF/mounting/QA/031017_14:02.checkXY_onQAQBAveAxis
a 031017_15:58 MTF/mounting/QA/031017_15:58.checkXY_DC
a 031017_16:07 MTF/mounting/QA/031017_16:07.checkXY_onQAQBAveAxis_COCN
a 031020_11:17 MTF/mounting/QA/031020_11:17.checkXY_cryostatCenter+2mm
a 031020_11:38 MTF/mounting/QA/031020_11:38.checkXY_cryostatCenter+2mm
a 031020_14:53 MTF/mounting/QA/031020_14:53.checkXY_internalCenterPost+2mm
a 031020_16:13 MTF/mounting/QA/031020_16:13.checkXY_internalCenterPost+3mm
a 031017_12:00 MTF/mounting/QB/031017_12:00.checkXY
a 031017_12:14 MTF/mounting/QB/031017_12:14.checkXY
a 031017_12:35 MTF/mounting/QB/031017_12:35.checkXY
a 031017_15:20 MTF/mounting/QB/031017_15:20.checkXY_DC
R 031017_17:01 MTF/mounting/QB/031017_17:01.checkXY_onQAQBAveAxis_trueAxis
R 031020_10:49 MTF/mounting/QB/031020_10:49.checkXY_cryostatCenter+2mm
R 031020_15:16 MTF/mounting/QB/031020_15:16.checkXY_internalCenterPost+2mm
R 031020_15:54 MTF/mounting/QB/031020_15:54.checkXY_internalCenterPost+3mm
=====
WarmBefore TC1
=====
a 031029_18:40 MTF/warmBefTC1/QA/031029_18:40.checkXY_ave_warmBefTC1
a 031029_18:57 MTF/warmBefTC1/QA/031029_18:57.checkXY_ave_warmBefTC1
R 031030_07:48 MTF/warmBefTC1/QA/031030_07:48.checkXY_warmBefTC1
R 031030_08:07 MTF/warmBefTC1/QA/031030_08:07.checkXY_roll
a 031031_09:23 MTF/warmBefTC1/QA/031031_09:23.checkXY_aftSurvey
a 031029_18:28 MTF/warmBefTC1/QB/031029_18:28.checkXY_ave_warmBefTC1
a 031029_19:08 MTF/warmBefTC1/QB/031029_19:08.checkXY_ave_warmBefTC1
R 031029_19:21 MTF/warmBefTC1/QB/031029_19:21.checkRoll_sag_repeat/031029_19:21.checkRoll_sag
R 031029_19:21 MTF/warmBefTC1/QB/031029_19:21.checkRoll_sag_repeat/031029_21:29.checkRoll_sag
R 031029_19:21 MTF/warmBefTC1/QB/031029_19:21.checkRoll_sag_repeat/031029_23:31.checkRoll_sag
R 031030_07:31 MTF/warmBefTC1/QB/031030_07:31.checkXY
=====
Cold, TC1
=====
a 031117_17:31 MTF/4.5K_TC1/QA/031117_17:31.checkXY_4.5K_AC
a 031117_18:00 MTF/4.5K_TC1/QA/031117_18:00.checkXY_4.5K_AC_onAve
a 031118_14:39 MTF/4.5K_TC1/QA/031118_14:39.checkXY_4.5K_AC_onAve_aftSurv
R 031118_14:57 MTF/4.5K_TC1/QA/031118_14:57.checkXY_4.5K_AC_onAve_aftSurv
a 031117_15:32 MTF/4.5K_TC1/QB/031117_15:32.checkXY_AC
a 031117_15:55 MTF/4.5K_TC1/QB/031117_15:55.checkXY_AC_sswGrd
a 031117_16:19 MTF/4.5K_TC1/QB/031117_16:19.checkXY_AC_sswGrd
a 031117_16:25 MTF/4.5K_TC1/QB/031117_16:25.checkXY_AC_sswGrd
a 031117_16:34 MTF/4.5K_TC1/QB/031117_16:34.checkXY_AC_sswGrd
a 031117_16:42 MTF/4.5K_TC1/QB/031117_16:42.checkXY_AC_sswGrd
a 031117_16:52 MTF/4.5K_TC1/QB/031117_16:52.checkXY_AC
a 031117_17:01 MTF/4.5K_TC1/QB/031117_17:01.checkXY_AC
a 031117_17:18 MTF/4.5K_TC1/QB/031117_17:18.checkXY_AC
R 031118_15:19 MTF/4.5K_TC1/QB/031118_15:19.checkXY_AC_onAve_aftSurv_repeat/031118_15:19.checkXY_AC_onAve_aftSurv
R 031118_15:19 MTF/4.5K_TC1/QB/031118_15:19.checkXY_AC_onAve_aftSurv_repeat/031118_15:34.checkXY_AC_onAve_aftSurv
R 031118_15:19 MTF/4.5K_TC1/QB/031118_15:19.checkXY_AC_onAve_aftSurv_repeat
a 031118_16:37 MTF/4.5K_TC1/QB/031118_16:37.checkX
a 031118_16:52 MTF/4.5K_TC1/QB/031118_16:52.checkX
a 031124_14:47 MTF/4.5K_TC1/QAQB/031124_14:47.roll_Q2aQ2b_1.9K_699A
R 031124_15:02 MTF/4.5K_TC1/QAQB/031124_15:02.roll_Q2aQ2b_1.9K_699A
a 031124_15:20 MTF/4.5K_TC1/QAQB/031124_15:20.xStr_Q2aQ2b_1.9K_699A_600g
a 031124_15:30 MTF/4.5K_TC1/QAQB/031124_15:30.str_Q2ab_1.9K_5460A
a 031124_15:59 MTF/4.5K_TC1/QAQB/031124_15:59.str_Q2ab_1.9K_11345A
a 031124_16:26 MTF/4.5K_TC1/QAQB/031124_16:26.roll_Q2ab_1.9K_11345A
=====
Warm after TC1
=====
a 031205_06:53 MTF/warmAftTC1/QB/031205_06:53.checkY
a 031205_10:12 MTF/warmAftTC1/QB/031205_10:12.checkXY_aveAxis
R 031204_17:27 MTF/warmAftTC1/QB/031204_17:27.checkXYroll_repeat/031204_17:27.checkXYroll
R 031204_17:27 MTF/warmAftTC1/QB/031204_17:27.checkXYroll_repeat/031204_18:18.checkXYroll
R 031204_17:27 MTF/warmAftTC1/QB/031204_17:27.checkXYroll_repeat
R 031205_07:13 MTF/warmAftTC1/QA/031205_07:13.checkXY
R 031205_07:35 MTF/warmAftTC1/QA/031205_07:35.roll
a 031205_10:01 MTF/warmAftTC1/QA/031205_10:01.checkXY_aveAxis
=====
Cold, TC2
=====
a 031208_11:24 MTF/4.5K_TC2/QA/031208_11:24.checkXY
a 031208_13:24 MTF/4.5K_TC2/QA/031208_13:24.roll
R 031208_16:02 MTF/4.5K_TC2/QA/031208_16:02.checkXY_aveAxis
a 031208_16:27 MTF/4.5K_TC2/QA/031208_16:27.roll_repeat/031208_16:27.roll
a 031208_16:27 MTF/4.5K_TC2/QA/031208_16:27.roll_repeat/031208_16:55.roll
a 031208_16:27 MTF/4.5K_TC2/QA/031208_16:27.roll_repeat
a 031209_12:50 MTF/4.5K_TC2/QA/031209_12:50.check_aveXY
a 031208_10:36 MTF/4.5K_TC2/QB/031208_10:36.checkXY
a 031208_10:51 MTF/4.5K_TC2/QB/031208_10:51.checkXY
a 031208_14:12 MTF/4.5K_TC2/QB/031208_14:12.roll
R 031208_15:29 MTF/4.5K_TC2/QB/031208_15:29.checkXY_aveAxis
a 031209_10:54 MTF/4.5K_TC2/QB/031209_10:54.roll_repeat/031209_10:54.roll
a 031209_10:54 MTF/4.5K_TC2/QB/031209_10:54.roll_repeat/031209_11:22.roll
a 031209_10:54 MTF/4.5K_TC2/QB/031209_10:54.roll_repeat/031209_11:50.roll
a 031209_12:34 MTF/4.5K_TC2/QB/031209_12:34.check_aveXY
a 031208_14:54 MTF/4.5K_TC2/QAQB/031208_14:54.roll
=====
Warm after TC2
=====
a 031214_23:06 MTF/warmAftTC2/QA/031214_23:06.checkXY_aveOnly
a 031214_23:16 MTF/warmAftTC2/QA/031214_23:16.checkXY_aveOnly
a 031214_23:58 MTF/warmAftTC2/QA/031214_23:58.checkXY_onAveAxis
R 031215_00:15 MTF/warmAftTC2/QA/031215_00:15.checkXYroll_onAveAxis_repeat/031215_00:15.checkXYroll_onAveAxis
R 031215_00:15 MTF/warmAftTC2/QA/031215_00:15.checkXYroll_onAveAxis_repeat/031215_00:46.checkXYroll_onAveAxis
R 031215_00:15 MTF/warmAftTC2/QA/031215_00:15.checkXYroll_onAveAxis_repeat/031215_01:18.checkXYroll_onAveAxis
R 031215_00:15 MTF/warmAftTC2/QA/031215_00:15.checkXYroll_onAveAxis_repeat
a 031214_23:27 MTF/warmAftTC2/QB/031214_23:27.checkXY_aveOnly
R 031214_23:41 MTF/warmAftTC2/QB/031214_23:41.checkXY_onAveAxis
R 031215_12:13 MTF/warmAftTC2/QB/031215_12:13.roll_aftSurv
a 031215_13:05 MTF/warmAftTC2/QB/031215_13:05.roll_aftSurv
=====
Cold, TC3
=====
a 031217_11:40 MTF/4.5K_TC3/QA/031217_11:40.check_aveXY_17K
a 031217_12:34 MTF/4.5K_TC3/QA/031217_12:34.checkXY_17K
a 031217_13:23 MTF/4.5K_TC3/QA/031217_13:23.roll_12K
R 031217_16:06 MTF/4.5K_TC3/QA/031217_16:06.checkXY_roll_4.5K_repeat/031217_16:06.checkXY_roll_4.5K
R 031217_16:06 MTF/4.5K_TC3/QA/031217_16:06.checkXY_roll_4.5K_repeat/031217_16:36.checkXY_roll_4.5K
R 031217_16:06 MTF/4.5K_TC3/QA/031217_16:06.checkXY_roll_4.5K_repeat/031217_17:09.checkXY_roll_4.5K
a 031218_11:46 MTF/4.5K_TC3/QA/031218_11:46.checkXY

```

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a 031218_12:54 MTF/4.5K_TC3/QA/031218_12:54.checkXY_aveOnly
a 031218_13:31 MTF/4.5K_TC3/QA/031218_13:31.checkXY_aveOnly
a 031218_13:43 MTF/4.5K_TC3/QA/031218_13:43.checkXY_aveOnly
a 031218_15:14 MTF/4.5K_TC3/QA/031218_15:14.checkXY_aftSurv_20K
a 031218_15:31 MTF/4.5K_TC3/QA/031218_15:31.checkXY_aftSurv_20K
a 031218_16:57 MTF/4.5K_TC3/QA/031218_16:57.checkXYroll_aftSurv_25K_repeat/031218_16:57.checkXYroll_aftSurv_25K
a 031218_16:57 MTF/4.5K_TC3/QA/031218_16:57.checkXYroll_aftSurv_25K_repeat/031218_17:32.checkXYroll_aftSurv_25K
a 031218_16:57 MTF/4.5K_TC3/QA/031218_16:57.checkXYroll_aftSurv_25K_repeat
a 031218_11:51 MTF/4.5K_TC3/QB/031217_11:51.check_axevy_17K
a 031218_16:28 MTF/4.5K_TC3/QB/031218_16:28.roll_aftSurv_20K
a 031217_12:07 MTF/4.5K_TC3/QB/031217_12:07.checkXY_17K
a 031219_07:06 MTF/4.5K_TC3/QB/031219_07:06.roll_aftSurv_40K
a 031217_14:21 MTF/4.5K_TC3/QB/031217_14:21.roll_12K
R 031217_15:45 MTF/4.5K_TC3/QB/031217_15:45.checkXY_4.5K
a 031218_07:09 MTF/4.5K_TC3/QB/031218_07:09.checkXY_4.5K_aveOnly
a 031218_07:24 MTF/4.5K_TC3/QB/031218_07:24.roll_4.5K
a 031218_07:55 MTF/4.5K_TC3/QB/031218_07:55.testX
a 031218_08:00 MTF/4.5K_TC3/QB/031218_08:00.roll_4.5K_repeat/031218_08:00.roll_4.5K
a 031218_08:00 MTF/4.5K_TC3/QB/031218_08:00.roll_4.5K_repeat/031218_08:32.roll_4.5K
a 031218_08:00 MTF/4.5K_TC3/QB/031218_08:00.roll_4.5K_repeat
a 031218_10:34 MTF/4.5K_TC3/QB/031218_10:34.roll_4.5K_onQBaxis
a 031218_11:21 MTF/4.5K_TC3/QB/031218_11:21.checkXY_onAveAxis
a 031218_13:16 MTF/4.5K_TC3/QB/031218_13:16.checkXY_aveonly
a 031219_07:26 MTF/4.5K_TC3/QB/031219_07:26.checkXY_aftSurv_40K
a 031219_08:17 MTF/4.5K_TC3/QB/031219_08:17.roll_15_625Hz_40K
a 031219_07:54 MTF/4.5K_TC3/QB/031219_07:54.checkX_freqTest_31.25Hz
a 031219_08:01 MTF/4.5K_TC3/QB/031219_08:01.checkX_freqTest_31.25Hz
a 031219_08:11 MTF/4.5K_TC3/QB/031219_08:11.checkX_freqTest_15.625Hz
a 031219_13:33 MTF/4.5K_TC3/QB/031219_13:33.testX_DC
a 031219_08:06 MTF/4.5K_TC3/QB/031219_08:06.checkX_freqTest_31.25Hz
a 031219_07:45 MTF/4.5K_TC3/QB/031219_07:45.checkX_freqTest_15.625Hz
a 031219_08:54 MTF/4.5K_TC3/QB/031219_08:54.roll_15_625Hz_40K_Bup5mm
a 031219_09:27 MTF/4.5K_TC3/QB/031219_09:27.roll_15_625Hz_40K_Bup5mm_Aup3mm
a 031219_10:01 MTF/4.5K_TC3/QB/031219_10:01.roll_15_625Hz_40K_Aup3mm
a 031219_13:43 MTF/4.5K_TC3/QB/031219_13:43.roll_15_QAOB_45K
a 031219_11:20 MTF/4.5K_TC3/QB/031219_11:20.roll_15_625Hz_40K_Aup3mm_repeat/031219_11:20.roll_15_625Hz_40K_Aup3mm
a 031219_11:20 MTF/4.5K_TC3/QB/031219_11:20.roll_15_625Hz_40K_Aup3mm_repeat/031219_11:52.roll_15_625Hz_40K_Aup3mm
a 031219_11:20 MTF/4.5K_TC3/QB/031219_11:20.roll_15_625Hz_40K_Aup3mm_repeat

=====
Warn after TC3
=====
a 040105_15:48 MTF/warmAftTC3/QA/040105_15:48.checkXY_aveOnly
R 040105_16:02 MTF/warmAftTC3/QA/040105_16:02.checkXY_aveAxis
R 040106_11:39 MTF/warmAftTC3/QA/040106_11:39.roll_repeat/040106_11:39.roll
R 040106_11:39 MTF/warmAftTC3/QA/040106_11:39.roll_repeat/040106_12:12.roll
R 040106_11:39 MTF/warmAftTC3/QA/040106_11:39.roll_repeat
a 040105_15:19 MTF/warmAftTC3/QB/040105_15:19.checkXY_aveOnly
a 040105_15:31 MTF/warmAftTC3/QB/040105_15:31.checkXY_aveOnly
a 040105_16:36 MTF/warmAftTC3/QB/040105_16:36.checkXYroll_aveAxis_repeat/040105_16:36.checkXYroll_aveAxis
a 040105_16:36 MTF/warmAftTC3/QB/040105_16:36.checkXYroll_aveAxis_repeat/040105_17:06.checkXYroll_aveAxis
a 040105_16:36 MTF/warmAftTC3/QB/040105_16:36.checkXYroll_aveAxis_repeat/040105_17:33.checkXYroll_aveAxis
a 040105_16:36 MTF/warmAftTC3/QB/040105_16:36.checkXYroll_aveAxis_repeat
R 040106_11:13 MTF/warmAftTC3/QB/040106_11:13.checkXY_aveAxis
R 040106_17:17 MTF/warmAftTC3/QB/040106_17:17.roll_repeat/040106_17:17.roll
R 040106_17:17 MTF/warmAftTC3/QB/040106_17:17.roll_repeat/040106_17:48.roll
R 040106_17:17 MTF/warmAftTC3/QB/040106_17:17.roll_repeat/040106_18:21.roll
R 040106_17:17 MTF/warmAftTC3/QB/040106_17:17.roll_repeat

```

Appendix C: Q2A/Q2B->MQXB06/MQXB05

Inside LQXB03, Q2A, closest to the MTF return can, the CDF side of the building, is MQXB06. Q2B, closest to the MTF feed can, away from CDF, is MQXB05.

Appendix D: Calculation of Integral Field Harmonics

Integral field harmonics are computed from the data taken during the longitudinal scan of the magnets. Reported data at each position are normalized at that position. The integral harmonics are computed as follows at a fixed current I .

$$\text{int } b_n = 10000 \frac{\int B_n dz}{\int B_2 dz} = \frac{\sum_{i=1}^n b_n(i) \bullet B_2(i)}{\sum_{i=1}^n B_2(i)} = \frac{\sum_{i=1}^n b_n(i) \bullet TF(i) \bullet I}{\sum_{i=1}^n TF(i) \bullet I} = \frac{\sum_{i=1}^n b_n(i) \bullet TF(i)}{\sum_{i=1}^n TF(i)}$$

We sum over the consecutive non-overlapping positions of the probe as indicated in the following figures. The measurements at 4.66 m (MQXB05) and 10.03 m (MQXB06) are not included in the sum. These two positions are special positions to match the interval defined as lead end during model magnet measurements.

Calculation of integral a_n is similar. Note that this procedure is different than that used for LQXB01 data and more correct.

